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# **Book: Marine Bioacoustic Signal Processing and Analysis**

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## **LONG-TERM GOALS**

Acoustic signal processing has long been the domain of electrical and mechanical engineers, physicists, and mathematicians. However, more and more biologists and psychologists are starting to use advanced signal processing techniques and analyses, especially with the influx of the many signal processing programs now available. What is lacking for many of these new users is an understanding of the theoretical underpinnings of different techniques. This has happened because the learning curve can be rather steep, especially for those in the biological and psychological sciences, and the theoretical constructs are often ignored or deemed too difficult to comprehend. This also applies to many students and beginning researchers with a physical science background, since various ideas and methodologies are scattered across different texts and manuscripts.

The goal of this project is to write a book on animal bioacoustics that brings together ideas, concepts and methods that are often found in diverse texts and manuscripts. We will approach basic principles from the perspective of processing and analyzing acoustic signals emitted by animals. The book will be aimed at advanced undergraduates and beginning graduate students – people with some background in sound analysis who come from a background in either an animal communication or signal processing. Our goal will be to make a practical guide by which people can understand and use the tools we have, rather than an theoretical exposition of the frontiers of our field. Such a book that is written with animal bioacousticians in mind is strongly needed in order for the field to grow in a good way. By making bioacoustic signal processing techniques available to a wider audience, we aim to advance the understanding and utility of marine bioacoustics.

## **OBJECTIVES**

The objective of this effort is to write and publish a book, *Marine Bioacoustic Signal Processing and Analysis*.

## **APPROACH**

This book will be co-authored by Dr. David Mellinger from Oregon State University and myself. We will meet 2-3 times per year to review any work done to date and to plan the writing of succeeding chapters. In between these meetings, we will write chapters and edit each others' work via email.

We plan to publish the book with the cooperation and assistance of the Acoustical Society of America. Au is on the editorial board of the ASA-Springer Verlag cooperative effort to have relevant book on acoustic written and published. The ASA has published a number of books with Springer-Verlag.

## **WORK COMPLETED**

Chapter 1 and Chapter 2 have been completed. The outline for these chapters are shown below:

### **Chapter 1: Marine Bioacoustics Signal Processing: Introduction**

- 1.1 The Decibel and Sound Pressure Level
- 1.2 The Signal to Noise Problem
  - 1.2.1 Binary Decision Matrix
  - 1.2.2 Receiver-operating characteristics curve
  - 1.2.3 Counting the Cost
- 1.3 Bioacoustics Signal Processing (Organization of This Book)

### **Chapter 2: Fourier Analysis**

- 2.1 The Time and Frequency Domains
- 2.2 The Fourier Transform
  - 2.2.1 The Impulse or Delta Function
  - 2.2.2 Fourier Transformation of Cosine and Sine Functions
  - 2.2.3 Negative Frequency in Fourier Transform
  - 2.2.4 More Fourier Transform Examples
- 2.3 Properties of the Fourier transform
  - Addition or Linearity Theorem
  - Time and Frequency Scaling
  - Time and Frequency Shifting
  - Modulation Theorem
  - Convolution Theorem
  - Correlation Theorem
  - Rayleigh-Parseval Theorem
- 2.3 The Discrete Fourier Transform and Fast Fourier Transform
  - 2.4.1 The Discrete Fourier Transform
  - 2.4.2 The Fast Fourier Transform
  - 2.4.3 Applying the FFT
  - FFT Leakage
    - FFT Windows
    - Digital Convolution

## **IMPACT/APPLICATIONS**

None

## **RELATED PROJECTS**

None